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Quantifying the effects of the maximum borehole depth on ground surface temperature histories inferred from borehole temperature profiles

Hugo Beltrami (1), Jason Smerdon (2), Gurpreet Matharoo (1), and Nick Nickerson (1)

(1) Environmental Sciences Research Centre, St. Francis Xavier University, Antigonish, Canada (hugo@stfx.ca), (2) Lamont-Doherty Earth Observatory of Columbia University, New York, New York, USA.

It is illustrated how the minimum depth of a temperature-depth profile impacts the estimation of the climate signal in a borehole temperature profile, and subsequently the derived ground surface temperature (GST) reconstruction. In particular, the effects and uncertainties that arise from the analyses of borehole temperature logs of different depths are quantitatively illustrated. Because the vast majority of measured borehole temperature profiles are acquired from boreholes of opportunity, the maximum measurement depth in data used for paleoclimatic studies varies considerably (beginning at depths as shallow as 100-150 m and extending to depths of more than 1 km). The depth of the borehole is important because the downwelling climatic signal must be separated from the quasi-steady state thermal regime established by the Earth's interior. This component of the signal is estimated as a linear increase in temperature with depth from the lower section of a borehole temperature profile, which is assumed to be unperturbed by recent climatic changes. The validity of this assumption is dependent on both the subsurface thermophysical properties and the character of the downwelling climatic signal. Such uncertainties can significantly impact the determination of the quasi-steady state thermal regime, and consequently the magnitude of the temperature anomaly interpreted as a climatic signal. Results demonstrate that widely different GST histories can be derived from temperature profiles truncated at different depths, even when the profiles are generated from the identical surface and subsurface conditions. Borehole temperature measurements approaching 500-600 m depths are shown to provide the most robust GST reconstructions spanning 500 to 1000 ypb, while shallower holes indicate a muted warming in the synthetic examples investigated. It is further shown that the bias introduced by a temperature profile of depths shallower than 500-600 m remains even if the time span of the reconstruction target is shortened.